| 日本―欧州　国際共同研究「超空間制御による機能材料」<br>2021 年度　年次報告書 | |
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| **研究課題名（和文）** | ナノ粒子からなる超分子構造体構築と多孔性ナノ材料への応用 |
| **研究課題名（英文）** | Nanoparticle Supramolecular Frameworks as Advanced Nanoporous Materials |
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| **所属・役職** | 東京大学　大学院工学系研究科・教授 |
| **研究期間** | 2019 年　4 月　1 日　～　2023 年　3 月　31 日 |

１．日本側の研究実施体制

| 氏名 | 所属機関・部局・役職 | 役割 |
|---|---|---|
| 相田　卓三 | 東京大学・大学院工学系研究科・教授 | 研究の総括 |

２．日本側研究チームの研究目標及び計画概要

This year we aim to construct a $AuNP^{GroEL}$ cluster using DNA hybridization between a DNA functionalized AuNP ($AuNP^{DNA}$) and a DNA functionalized chaperonin GroEL ($GroEL^{DNA}$). Two strategies will be investigated; one-pot and stepwise synthesis. We already succeeded in comonomer synthesis, however, the purification of comonomers with desired number of GroEL/AuNP needs further investigation. We will focus more on the one-pot strategy due to ease of synthesis, purification, and possible control in the pore size. AuNP of different core sizes (5–30 nm), different lengths of DNA on AuNP and GroEL (10–30 base pair) will also be investigated.

3．日本側研究チームの実施概要

In the academic year 2021, we constructed nanoparticle supramolecular frameworks both via a one-pot strategy and via a stepwise strategy with a $^{GroEL}$AuNP comonomer with a 5 nm AuNP core. The growths of these frameworks were probed by dynamic light scattering (DLS), shedding light on their slow kinetics, on the time scale of hours, and on their dynamic natures. In addition to DLS, transmission electron microscopy (TEM) and cryo-TEM were used to characterize the structures of the frameworks. Following promising results from these 2D imaging techniques, the 3D structures of the frameworks were characterized quantitatively by cryo-TEM tomography, which showed characteristic AuNP-to-AuNP spacings of 30-35 nm, and 70-75 nm, in the cases of frameworks having a single GroEL unit, and a GroEL trimer, respectively, linking adjacent AuNPs. This was in good correspondence to the expected spacings based on the sizes of individual components.

We confirmed that the frameworks retained the ATPase activity of their constituent GroEL units. Using flow cytometry, we probed the ability of the as formed frameworks of 30-35 nm AuNP spacing to accommodate guests within their internal porous structures by using dye-labelled, poly(ethylene glycol)-appended GroEL as a large model guest. A size-dependent guest selectivity was found, with guests of hydrodynamic diameter ($D_h$) less than 45 nm being accommodated. Further investigations into the loading of functional guests and ATP-dependent guest release, as demonstrations of nanorobotic functions are ongoing.